Space Weather Technical Forecast

Issued on Saturday, 10 February 2024 at 01:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Current S2 conditions likely declining. Further R1-R2 Radio Blackouts Likely. Slight Chance G1 to start, increasing into the period.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded at GOES16 has been High over the past 24 hours, with one major X-class flare observed, this seeing a peak recorded magnitude of X3.3 at 09/1314UTC, and most likely associated with Ex-AR3575 which now lies over the southwestern limb. AR3576 produced two M-class flares; a M3.1 at 09/0041 UTC and an M1.2 at 09/1800 UTC.

There are currently six numbered regions on the visible disc, with the likely source of the recent significant flare activity, Ex-AR3575, no longer visible over the southwestern limb. AR3576 remains dominant in terms of complexity and size. There has been some slight development in the collections of spots on its leading northern edge, however the complex internal structure appears largely unchanged, and there remain at least two delta regions within its central portion. Other spots on the facing side were unremarkable by contrast.

No clear Earth directed Coronal Mass Ejection (CME) observed in available coronagraph imagery, although investigation continues surrounding the most recent M-Class flare associated with AR3576. Other CME-generated events were largely associated with the off-going southwestern limb regions of Ex-AR3575, Ex-AR3564, with no Earth effects anticipated. This includes the significant CME associated with the X3.3, with this feature recording and an associated 1000 sfu Tenflare, a type IV radio sweep, and a major partial halo CME beginning at 09/1325 UTC. This CME is not expected to have any significant Earth-directed component given its position beyond the limb although some shock enhancement cannot be completely ruled out.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE and DSCOVR at L1, were initially Slightly Elevated, with speeds near 480km/s with a slowly declining trend. Winds declined to a minimum of around 380km/s before a shock was observed, commencing around 09/2140UTC. This likely the glancing arrival of the 06 Feb CME, resulting in winds increasing to around 490km/s, before subsequently declining to around 440km/s by the end of the period. This general evolution applied to most solar wind characteristics, with density generally average, peaking around 10ppcc just before CME arrival. The IMF generally weak below 6nT but briefly peaking into moderate levels with the CME arrival. The north-south component varying weakly between -4 and +7nT, and largely positive following CME arrival. The mainly positive phi angle (away from the Sun) changed to increasingly negative later in the period. Geomagnetic activity generally Quiet, but with Unsettled condition (Kp3) recorded following the CME arrival.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux rose steadily following the X3.3 flare, rising above S1 levels (10pfu) from 09/1549UTC and S2 levels (100pfu) from 09/1815UTC, where despite some slight fluctuations it remains.
GOES16 high energy (greater than 2MeV) electron flux remained at Normal Background levels. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold and

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has had a flat trend, with a 10/0001UTC fluence value of 1.04e6pfu observed.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate X-ray flare activity likely, and a slight chance of further X-class activity, with AR3576 providing the vast majority of the risk as Ex-AR3575 continues to rotate away around the limb.

Solar Wind / Geomagnetic Activity: Multiple glancing CMEs may feature in the period: firstly likely ongoing from the M4.2 on 06 February which may bring a very slight Chance of G1 inside the coming 24 hours, and then a second event from the 08/2030UTC filament eruption, that brings a Chance of G1 into day 3 (12 Feb). Overall a Slight Chances of G1 to start the four-day period, with generally Quiet to Unsettled conditions expected. A chance of G1 conditions following into days 3-4 given the potential for CME enhancement both from those mentioned above but also any further events, most likely associated with AR3576.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux currently at S2 levels following earlier enhancement from the X3.3 flare. The high energy proton flux should begin to subside through day 1 (10 Feb), although likely persisting into day 2 (11 Feb) above background levels, and there will remain an elevated potential to rise above the S1/Minor Radiation Storm level in response to any significant flares into the period.
High energy electron flux (greater than 2MeV) is expected to continue at current Normal Background levels, with the associated 24-hour electron fluence remaining well below the Active threshold.

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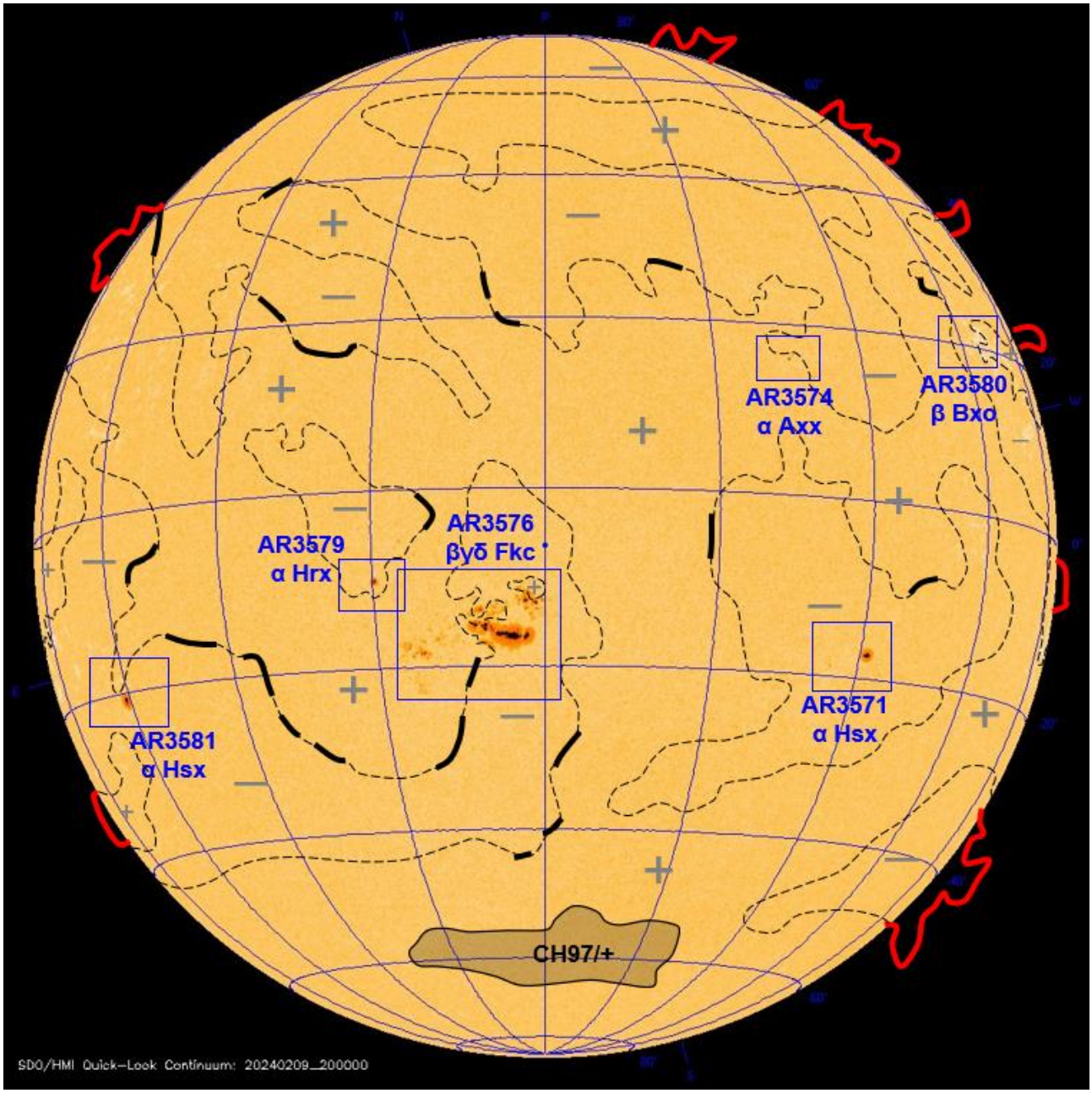
Figure 1. Solar Analysis Valid 09/2000UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The current Slightly Elevated solar wind is perhaps most likely derived from a CME that left the Sun in association with the M4.2 flare early on the 06 Feb, this bringing a very slight chance of a G1/Minor Geomagnetic Storm interval, however significant geomagnetic activity now looks unlikely. Prior to the arrival of this feature solar winds displayed a slowly declining signal and the only other coronal hole feature present on the disc, CH97, lies at low solar latitude and noteworthy impacts are not expected.

With regard further CME activity, analysis of the 08/2030UTC south-centre filament eruption now carries a chance of G1 conditions into day 3 (12 Feb). This feature is modelled as crossing 1AU, mainly behind and below the Sun-Earth line around 12/1200UTC. Given the slow transit time, geomagnetic effects will probably be largely contained within the same UTC day, with any later arrival likely less impactful. The risk complicated by the potential for any shock effects from the large CME associated with the X3.3 event. Despite the position of this event around the southwest limb, given the size of the eruption and position of the parker spiral some shock enhancement may be possible, perhaps most likely into day 3 (12 Feb) although very low confidence.

There is therefore a Slight Chances of G1 to start the four-day period, with generally Quiet to Unsettled conditions expected. A chance of G1 conditions following into days 3-4 given the potential for CME enhancement both from those mentioned above but also any further events, most likely associated with AR3576.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	5	30	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
08/2030	Partial	Filament Eruption	S centre	641km/s	12/1200UTC	Glancing Blow

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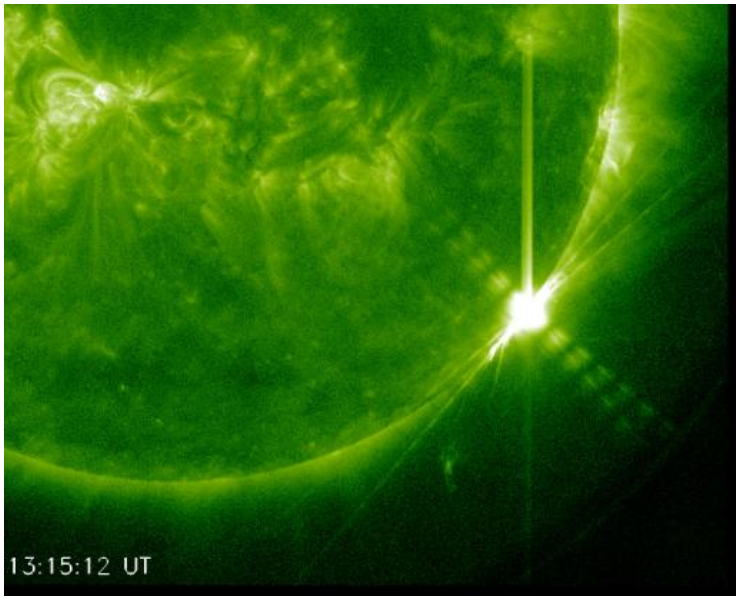
Radio Blackouts - X-Ray Flares:
The risks of flare activity are now dominated by AR3576 near centre-disc with the passing of Ex-AR3575, although the latter does still factor into the probabilities initially due to the possibility it throws emissive ejecta high into the corona, as seen in the past 24 hours.

The daily risk of significant flares is maintained through the period with further M-class flares considered likely from AR3576, with a Slight Chance of X-class. The returning Carrington locations for several past regions are due over the eastern solar horizon in the period - the flux emanating from the first of these is now visible in AIA171 over the southeastern solar horizon, however any contribution from these regions will be assessed as and when they appear over the eastern solar horizon.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	Yes	20	20	20	20

Figure 2: SDO/AIA 94 imagery and GOES16 24hr X-Ray trace showing X3.3 flare likely associated with Ex-AR3575



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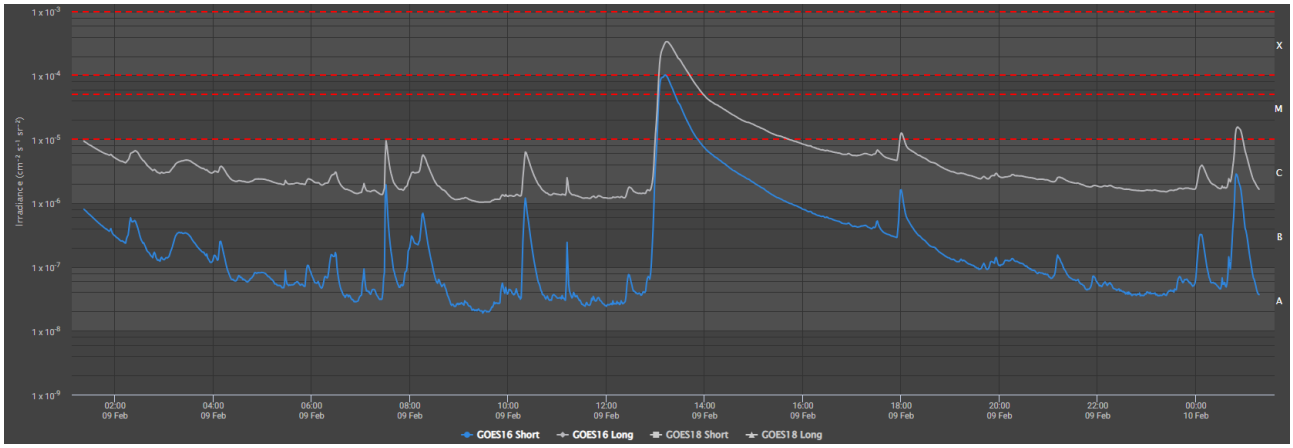

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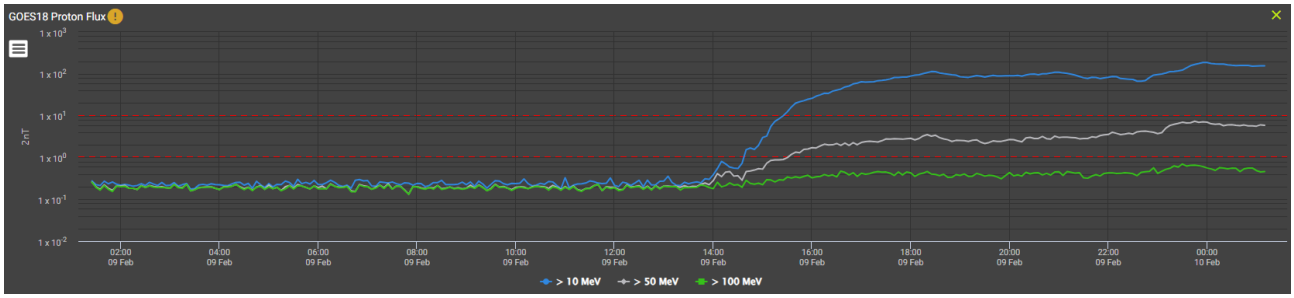
Solar Radiation Storms - (High Energy Protons):
GOES18 high energy (greater than 10MeV) proton flux is currently at S2 levels following earlier enhancement from the X3.3 flare, most likely associated with Ex-AR3575. The high energy proton flux should begin to subside through day 1 (10 Feb), although likely persisting into day 2 (11 Feb) above background levels. There will likely remain an elevated potential to rise above the S1/Minor Radiation Storm level in response to any significant flares into the period, these flares remain possible from Ex-AR3575 in the short term but increasingly from AR3576 as it rotates further into the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	99	60	30	20
Very Active	**≥ S3 ***	No	2	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: Latest GOES18 Proton Flux 24hr trace



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High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) as observed by GOES16 is expected continue at mainly Normal Background levels, given the expected absence of significant fast wind streams and glancing incidence of any CME activity.

The associated 24-hour electron fluence is expected to remain well below the Active (1e8 integrated flux) threshold, as suggested by MOSWOC REFM, although the current forecast period is likely to move away from a predictable coronal hole fast/slow pattern and more towards a threat of CMEs given AR3576's position on the disc, rendering REFM less reliable.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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